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Development of novel cosmetic formulation using spherical cellulose beads, "feeling like using silicone elastomer beads"

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Introduction:

Spherical cellulose beads will be the one of the best candidate alternating microplastics beads, since it is the degradable product in the nature (under the regulation of OECD 301F and ASTM D6691 for the biodegradability in marine). In recent year, silicone elastomer beads have been widely used in cosmetics application, liquid and powder foundations. This product can give very good moist and smooth feeling in application. However, this product, silicone elastomer beads, is the microplastics, so that it is inevitable to find the alternative product. Although spherical cellulose beads have almost same shape as silicone elastomer beads, it shows different characteristics compared with silicone elastomer beads, such as harder mechanical property and less creamier nor smoother feeling.

In this study, we evaluated the texture of liquid and powder foundation by human sense, and we developed novel cosmetic formulation feeling like using silicone elastomer beads. The formulation using metal soap surface treated cellulose beads and synthetic mica shows the almost same moist and smooth feel using silicone elastomer beads.

Materials:

1. Spherical cellulose beads (INCI Name: Cellulose)

The particle size of cellulose beads is 5-15µm, and we have used non treated powder itself and metal soap surface treated one in comparison. As a comparison, silicone elastomer beads (INCI Name: Vinyl dimethicone/methicone silsesquioxane crosspolymer) and spherical silica beads (INCI Name: silica) were evaluated with spherical cellulose beads.

2. Synthetic mica (INCI Name: Synthetic fluorophlogopite)

The particle size of synthetic mica is 5-20µm, and we have used non treated powder itself and metal soap treated one in comparison.

3. Surface treated pigments

Spherical cellulose beads and synthetic mica were treated with metal soap (MS). MS treated pigments show water repellency and superior dispersibility in oil. In this study, MS treated pigments contribute to the development of a similar moist and smooth feel using silicone elastomer beads. In case of liquid foundation, titanium dioxide and iron oxides were treated with polyglyceryl-2 tetraisostearate (P2T). P2T treated pigments show excellent dispersibility in various oil, and it allows to skip premix process for saving manufacturing time. Pigments treated with MS and P2T were obtained from Daito Kasei Kogyo Co., Ltd.

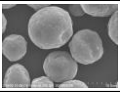
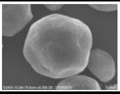
Results & Discussion:

1. Biodegradability of spherical cellulose beads

The biodegradability of the cellulose beads was made evaluation by the methods of Organization for Economic Co-operation and Development (OECD) 301F and American Society of Testing Materials (ASTM) D6691. According to OECD 301F, the degree of biodegradation should be over 60% after 28 days for biodegradable substance. The degree of biodegradation of the cellulose beads in this study was 68% after 28 days surpassing the threshold by 7%. ASTM D6691 is the method for measuring biodegradability in seawater. Biodegradable substances should degrade over 90% after 6 months. Cellulose beads showed a very high biodegradability, which was 93% after 28 days and surpassed the threshold by 3.6% in just 1 month. From these results, the spherical cellulose beads will be biodegradable polymers.

2. Evaluation results of spherical cellulose beads

Table-1 Comparison of spherical cellulose beads and silicone elastomer beads

	Cellulose beads-5	Cellulose beads-10	Silicone elastomer beads
Particle size (µm)	8～10	12～15	12
Total transmission Td (%)	0.59	0.71	1.40
Haze index H(%)	53.1	33.1	1.40
Surface area (m^2/g)	1.30	1.80	1.35
Oil absorption (ml/100g, oleic acid)	47.7	42.6	49.0
SEM image (x 5000)			

Hardness

We evaluated hardness by a micro compression tester. Table-2 shows the result of required compressive force to deform 10%.

Table-2 Compressive force required to deform particles by 10%.

	Compression force	Calculation compression ratio	Shape	Particle size	Collapse
	P (mN)	(%)		(µm)	
Cellulose beads-5	3.09	10	Spherical	8～10	No
Cellulose beads-10	5.74	10	Spherical	12～15	No
Silica beads	119.6	10	Spherical	10	Broken
Porous silica beads	1.29 (*)	10	Porous sphere	5	Broken
Silicone elastomer beads	2.5	10	Spherical	12	No

The compressive force of cellulose beads required for 10% displacement is almost same as silicone elastomer beads. This effect contributes to a moist and smooth feel on the skin.

3. W/O liquid foundation

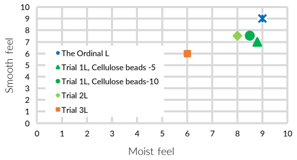
We evaluated in w/o liquid foundation (Table-3, Fig.-1). The main oil in liquid foundation is natural origin C9-12 alkane.

Table-3 Composition of liquid foundation

	The Ordinal L	Trial 1L	Trial 2L	Trial 3L
Beads	Silicone elastomer beads	Cellulose beads -5/-10	Cellulose beads -10	Silica beads
Surface treatment of beads	None	MS*1	None	None
Oil Phase	28.9%	29.4%	29.4%	29.4%
Surface treated*1 Synthetic mica	-	10.0%	10.0%	10.0%
Various beads	8.0%	4.0%	4.0%	4.0%
Surface treated*2 color pigments	10.0%	10.0%	10.0%	10.0%
Water phase	53.1%	46.6%	46.6%	46.6%
Total	100.0%	100.0%	100.0%	100.0%

*1 MS treated pigments: Cellulose beads-5, Cellulose beads-10 and synthetic mica
*2 P2T treated pigments: Titanium dioxide and iron oxides

Fig.-1 Texture evaluation of liquid foundation by human sense (N=5)



By using cellulose beads, Trial 1L shows better moist and smooth feeling than Trial 2L. According to the result of Trail 1L, the smaller size of spherical cellulose beads shows better moist than the bigger one. The bigger one shows good balance of moist and smooth feel.

4. Powder foundation

We evaluated in powder foundation (Table-4, Fig.-2). Furthermore, we evaluated the compact stability with drop test from 50cm, 3 times (Table-5).

Table-4 Composition of Powder foundation

	The Ordinal P	Trial 1P	Trial 2P	Trial 3P
Beads	Silicone elastomer beads	Cellulose beads -10	Cellulose beads -10	Silica beads
Surface treatment of beads	None	MS*1	None	None
(Powder Phase)				
Color Powder	93.0%	83.0%	83.0%	83.0%
Various beads	7.0%	7.0%	7.0%	7.0%
Surface treated*1 Synthetic mica	-	10.0%	10.0%	10.0%
Total of powder compound	100.0%	100.0%	100.0%	100.0%
(Final compound)				
Powder phase	95.0%	95.0%	95.0%	95.0%
Olive squalene	5.0%	-	-	-
Vegetable (olus) oil	-	5.0%	5.0%	5.0%
Total of final compound	100.0%	100.0%	100.0%	100.0%

*1 MS treated pigments: Cellulose beads-5, Cellulose beads-10 and synthetic mica

Fig.-2 Texture evaluation of powder foundation by human sense (N=5)

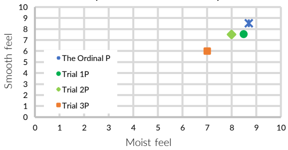


Table-5 Compact stability of powder foundation

	The Ordinal P	Trial 1P	Trial 2P	Trial 3P
Drop test result of Powder Foundation (50cm x 3 times)				

By using cellulose beads, Trial 1P shows better moist and smooth feeling than Trail 2P, and it shows almost same texture as The Ordinal P. According to the result of Trial 3P, the moistness and smoothness were insufficient. In case of powder foundation, it should be better to use paste-like oil binders, such as vegetable (olus) oil, petrolatum or butyrospermum parkii (shea) butter in the formulation to obtain the similar feeling using silicone elastomer beads.

Conclusions:

By the combination of spherical cellulose beads and synthetic mica, liquid and powder foundations showing silicone elastomer beads-like moist and smooth feel could be prepared. Furthermore, by using MS treated spherical cellulose beads and synthetic mica instead of non-treated ones, which showed much better moist and smooth feeling almost same as using silicone elastomer beads. In case of powder foundation, that with spherical cellulose beads showed excellent compact stability against drop test.

Changing silicone elastomer beads into spherical cellulose beads, we are able to solve microplastics issue and obtain the same characteristics as utilizing silicone elastomer beads with the technique of novel cosmetic formulations with combination of the other ingredients.